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THE USE OF TRACER AS A MARKSMANSHIP AID WITH UNZEROED RIFLES IN DAYLIGHT

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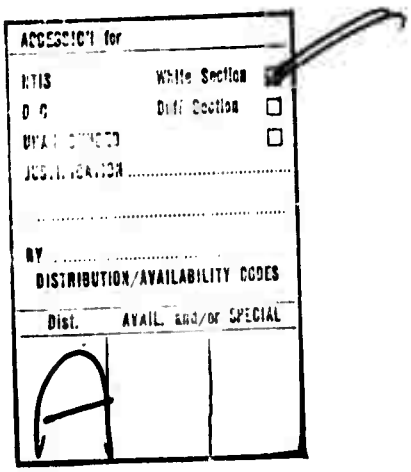
March 1974



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Each of 12 infantrymen engaged targets at a nominal 500-meter range firing up to 17 rounds per target engagement of ball or tracer ammunition in daylight semiautomatically from an M14 rifle whose sights were biased two standard deviations either high or low in a test of the hypothesis that tracer ammunition would provide a marksmanship aid. Analyses of hit and rate of fire data showed no statistically significant differences as a function of either ammunition type or sight bias.

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THE USE OF TRACER AS A MARKSMANSHIP AID WITH UNZEROED RIFLES IN DAYLIGHT

INTRODUCTION

The purpose of the Human Engineering Laboratory (HEL) Tracer Program is to determine the increase in effectiveness, if any, of tracer ammunition over ball ammunition in the infantry ground-to-ground role. The general approach to be followed in making this determination and the experimental methods to be employed are discussed in (5).

In Tracer Experiment 1, which was conducted in part to obtain baseline data on the performance of selected[1] infantrymen firing 7.62mm tracer in daylight, no significant differences were found in the accuracy and rate of fire data between ball and tracer ammunition. Further, the subjects' aiming errors calculated from the data proved smaller than expected (4,pp. 21-23). It was hypothesized that the fact that all subjects had obtained a battlesight zero with their weapons prior to firing the test course might have served to mask potential performance differences as a function of ammunition type.

The purpose of this experiment was to determine whether differences in performance measures as a function of ammunition type would occur if subjects fired from unzeroed weapons.

METHOD

Range Layout

This experiment was conducted in the spring of 1973 on Griswold Range, Ft. Benning, Georgia. Exactly the same terrain (including firing point and target locations) was used as in the previous study (4, pp. 6-7). However, only targets at a nominal 500-meter range were used (inasmuch as the use of tracer in daylight is widely believed to be more beneficial at longer ranges than at shorter ranges).

Instrumentation

Two data collection systems were used:

Electronic System.[2] This system used an Esterline–Angus Event Recorder to transcribe inputs from three sensors:

a. Target Exposure Time – was indicated by a mercury switch affixed to the bottom of each target frame. The switch closed when the target reached approximately the midpoint in its travel up, and opened when the target reached the same position in its travel down.

[1] Criteria were 20/40 vision (or better) and no combat experience.

[2] Designed by Otho C. Wolfe.

b. Rate of Fire – was indicated by an acoustic transducer and amplifier located to the left front of the firing point.

c. Target Hit – was indicated by a bullet passing through and causing momentary closure of the normally open circuit between the metal front and rear of each E-type silhouette target.

Photographic System[3]. Miss distance data were gathered by a lightweight 16mm camera mounted on and aligned with the barrel of each of the three M14 rifles used in the test (Figure 1). The camera took one photograph of the target area approximately 8 milliseconds before the hammer struck the rear of the firing pin in the weapon. An example of such a photograph is shown in Figure 2. Miss distances of projectiles from their intended targets were to be calculated by the technique explained in (6).

Subjects

Subjects were 12 enlisted men holding infantry MOS from units at Ft. Benning. All had completed advanced individual training, but none was a combat veteran. The characteristics of this subject group were approximately the same as those of the subjects who participated in Tracer Experiment 1 (4, p.A-9).

Procedure

The test subjects had previously participated in Tracer Experiment 7 which was conducted on the same terrain. They were therefore familiar with the use of the M14 rifle in field firing exercises with both ball and tracer ammunition. They had also been given training in and had practiced employing the principle of the adjusted aiming point (2, pp. 52-53). In their orientation to this experiment (Appendix A), the subjects were asked to simulate a tactical situation in which their own (presumably zeroed) rifle became inoperative and they were required to bring fire on the enemy using someone else's weapon.

The experimental hypothesis for this test was that the number of target engagements terminating in a hit would be significantly greater – regardless of sight bias – when tracer ammunition was fired than when ball ammunition was fired.

The experiment employed a simple 2 x 2 design with events ordered as shown in Figure 3. Independent variables were:

Ammunition Type

Ball, M80

Tracer, M62

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[3]Designed by Zoltan Kocsis and produced by the Strauss Photo-Technical Service, Inc. of Washington, DC.

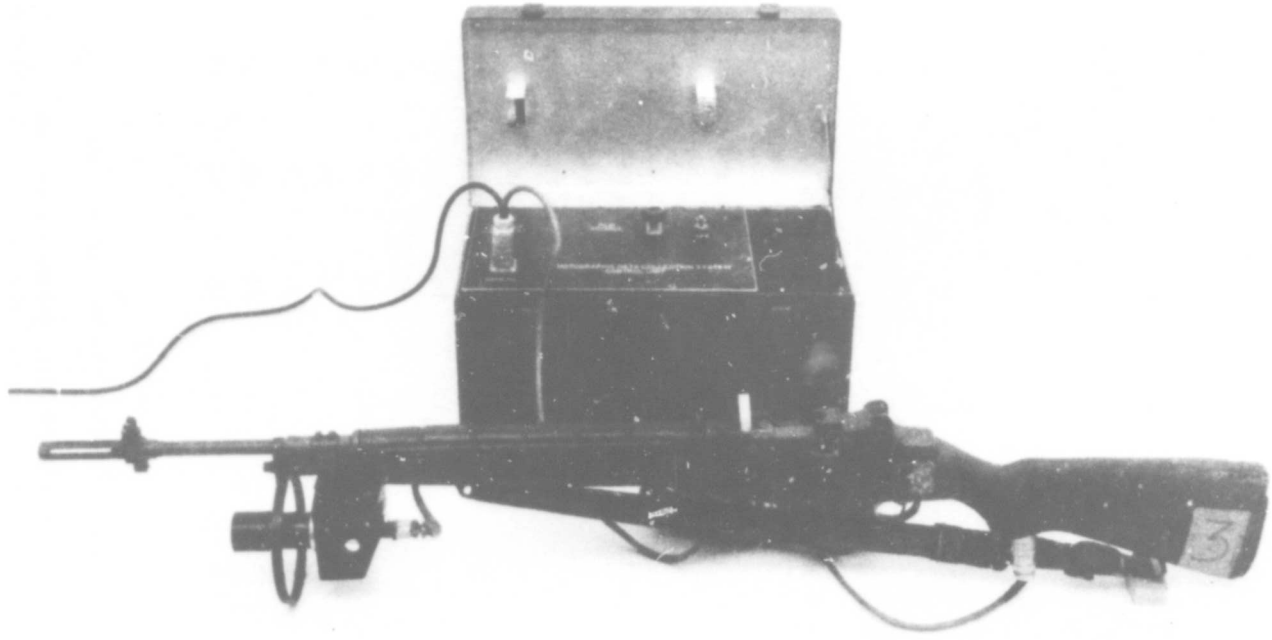

Fig. 1. Gun-camera miss distance indicator system.

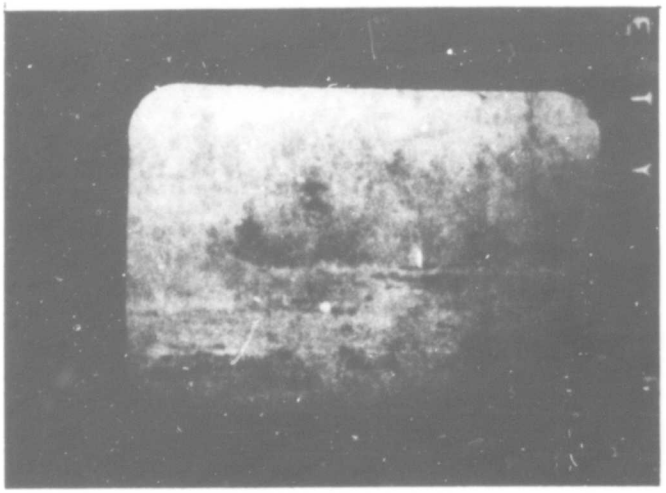

Fig. 2. Photo of target at 300 meters taken with gun-camera.

Subject Number	Sequence Number and Event			
	1	2	3	4
201	HT	LB	HB	LT
202	HT	LT	LB	HB
203	HT	HB	LT	LB
204	LB	LT	HB	HT
205	HT	LT	HB	LB
206	LB	HB	LT	HT
207	HB	HT	LB	LT
208	LT	HB	HT	LB
209	HT	LT	HB	LB
210	LB	HB	LT	HT
211	HB	HT	LB	LT
212	LT	LB	HT	HB

Legend

HB = Sight biased high, ball ammunition

HT = Sight biased high, tracer ammunition

LB = Sight biased low, ball ammunition

LT = Sight biased low, tracer ammunition

Fig. 3. Experimental design.

Sight Bias

High (24 clicks elevation, 8 clicks right windage)

Low (8 clicks elevation, 8 clicks left windage)

The rear sight settings used in this experiment were determined by doubling the standard deviation of the differences between the initial sight setting of 16 clicks elevation, zero windage recommended in (2) and the actual battlesight settings of the subjects in Tracer Experiment 1. The sight biases achieved by this process at 500 meters were, respectively, 3.7 feet each high and right and 3.7 feet each low and left.[4]

Subjects fired the test course (consisting of four target presentations against each of which they were allowed a maximum of 17 rounds) one at a time. Sight bias was preset on two weapons (one high, right and one low, left), the rear sights were tightened, and subjects were instructed not to attempt to make sight changes – but to hit the targets by the use of an adjusted aiming point.

RESULTS

The number of hits and the number of rounds fired for each condition by each shooter are shown in Table 1. The first round hit by subject number 202 was determined to be an outlier (3, p. 8) and was discarded from the data. Because the actual number of hits in the data was small, a separate analysis was performed to determine the effects of each independent variable. A 2 x 2 contingency table (1, p. 142) was constructed for each variable, as follows –

Type of Ammunition	Hit Missions	Miss Missions
Ball	5	18
Tracer	8	16

Sight Bias	Hit Missions	Miss Missions
High	6	18
Low	7	16

The chi square statistics for the two tables[5] were .789 and .173 respecively; neither is significant at the .1 level. As a check on the effect of ammunition type, the u_2 statistic (5, p. H-2), which is somewhat subject to Type 1 (alpha) error, was also calculated on the ratio of hit missions to total missions. The resulting value of .560 is not significant at the .1 level.

The effect of the independent variables on the rate of fire[6] data was examined in a two-way analysis of variance (Table 2). None of the F tests was statistically significant.

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[4]One click in either elevation or windage moves the point of impact 2.8 cm for each 100 meters of target range. For an 8 click adjustment, the strike of the round is shifted 8 x 2.8 cm x 5 = 112 cm = 3.7 ft.

[5]Using a one-tailed test for ammunition type and a two-tailed test for sight bias.

[6]Defined as the "time between" rounds; hence, excluding the time to fire round one.

TABLE 1

Summary of Hit Data
(Expressed as hits/number of rounds fired)

Subject Number	Experimental Condition			
	Ball Ammunition		Tracer Ammunition	
	Sight Bias High	Sight Bias Low	Sight Bias High	Sight Bias Low
201	0/17	0/17	1/6	0/17
202	0/17	1/1*	0/17	0/17
203	1/8	0/17	0/17	0/17
204	0/17	0/17	1/5	1/16
205	0/17	1/5	1/15	0/17
206	1/11	0/17	0/17	0/17
207	0/17	1/5	0/17	1/15
208	0/17	0/17	1/16	0/17
209	0/17	0/17	0/17	1/10
210	0/17	1/8	0/17	0/17
211	0/17	0/17	0/17	1/7
212	0/17	0/17	0/17	0/17

TABLE 2

Summary of Analysis of Variance
of Rate of Fire Data

Source	df	ms	F
Ammunition Type (A)	1	1.218	.669
Sight Bias (S)	1	≈ .000	.000
A x S	1	2.130	1.170
Error	40	1.820	

Having found no significant difference in either hit or rate of fire data as a function of ammunition type, it becomes particularly important to analyze the miss distance data to determine whether (as hypothesized in 4, p. B-1) there are true and potentially significant differences in the soldiers' aiming patterns which our performance measures have not detected. Given a knowledge of the point of aim of each round fired in the test, the index of proximity (I_p) statistic (6) can be used to test the experimental hypothesis (p. 3 above).

Analysis of the gun-camera films showed that, of the 705 rounds fired in this experiment, there was readable film for only 32. Moreover, of these, there was only one mission in which there was readable film for every round (as required by the I_p statistic).

The disappointing results of the gun-camera data are traceable largely to the irregularity of voltage at the firing point. Less than the required 110 volts entering the camera control unit caused the film advance mechanism to malfunction, resulting in a number of double and triple exposures. In addition, there were films which appeared to be underexposed.

DISCUSSION

In the previous test, infantrymen firing M14 rifles(with which they had previously obtained a battlesight zero) against pop-up E-type silhouette targets at a nominal 500-meter range in daylight attained nearly equal hit probability with ball and tracer ammunition (4, p. 16). In this test, another group of 12 infantrymen drawn from the same units fired on the exact same course with ball and tracer ammunition, but with M14 rifles whose rear sights were biased away from the normal range of battlesight zero settings. Analysis of hit and rate of fire data showed no statistically significant differences as a function of either sight bias or ammunition type.

It is conceded that the sample size of the data in this test is small and could theoretically have masked a potential increase in "effectiveness" of tracer as a function of some greater number of rounds. Balancing that implication, however, is the military significance of the fact that an infantryman who has fired 17 rounds against a single personnel target of opportunity without achieving a hit is likely to have revealed his position, consumed an inordinate amount of the ammunition he is carrying and suggested to the enemy target that his marksmanship poses no threat.

There is a widely-held belief (7, p. 6-2) that, in addition to the other roles postulated for it (5, p. B-2), tracer provides the individual rifleman with information which enables him to bring more effective fire upon enemy personnel targets in daylight. The data from Tracer Experiment 1 (4) and from this test do not support that contention.

CONCLUSIONS

1. The use of tracer ammunition in daylight does not provide an individual rifleman any significant increase in effectiveness (by common measures) against pop-up targets at a nominal 500-meter range when he fires with a weapon whose rear sight is biased away from the normal range of battlesight zero settings.

2. The direction of sight bias (high, right or low, left) does not affect either hit probability or rate of fire.

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APPENDIX A

STANDARDIZED INSTRUCTIONS

SUBJECTS' ORIENTATION TO TEST

NOTE: Orientation will be given from position behind the firing point.

This afternoon your firing on Griswold Range will be somewhat different from that you've done on previous days and that which you will do in the remainder of Tracer Experiment 7. We're going to suspend that experiment now, and instead do some shooting to answer another question.

This afternoon you will each fire only four missions from the firing point in front of you. You'll have two targets with ball ammunition, and two with tracer. They will be the same size, shape and color as you've fired on before. When each target comes up, we want you to try to hit it as quickly as possible – firing well-aimed shots. The target will go down as soon as you hit it. When you see the target disappear, stop firing.

"OK, what's new?" you say. This afternoon you will have a different situation than before. In this situation, which I'll read to you in a moment, you will not be firing the rifle you zeroed at the beginning of this experiment. Instead, you'll be firing weapons someone else zeroed. You probably know that, for any given rifle there is no one correct zero. The zero depends on the shooter: the shape of his head, and the way he holds the weapon. So you (point to one subject) could have one zero for a weapon and you (point to another subject) could have a different zero for the same weapon. And both would be correct.

In this afternoon's firing, you're going to shoot two weapons each of which has been zeroed by someone else. It may be that at least one of those weapons may have a zero that's comfortable for you. In any case, we don't want you to change the sight setting on the weapon. If, after firing a round or two, you decide that the zero on the weapon isn't correct for you, use the principle of "hold-off" to engage the target.

For each of your four missions, the firing point operator will issue you a magazine of 17 rounds. And this is the situation he will read you:

Pretend you're in a hasty defensive position on this hill. An enemy patrol has begun firing on you. Just as you start to return fire, the firing pin breaks in your rifle. You look around and see another rifle nearby. You pick it up and use it to bring fire on the enemy. Fire well-aimed shots as quickly as possible. Keep firing until the target drops or you're out of ammunition. Are you ready? Unlock your weapon. Watch the range!

Once again, as soon as the firing point operator says "Watch the range," that's your clearance to fire. It means that your target is about to come up. As soon as you see it, commence firing well-aimed shots as quickly as possible. But do not adjust the rear sight on the weapon.

Do you have any questions about what we're going to do this afternoon?

OK. First man stay here. The rest of you move back to the holding area.

INSTRUCTION SET 1

NOTE: Begin on green light. If red light comes on, immediately say, "Cease fire. Lock your weapon. Relax."

Say to the subject as he stands behind the FP–

You are now going to do test firing.

At this time, check to see that your weapon is clear. (NOTE: Verify.) I'm now going to connect the power cable to your gun-camera and put the film in it.

(NOTE: Do so.)

At this time, pull the operating rod back and put the safety on. Now your gun-camera is ready to take a picture. Get into a good prone position facing the I-D board. Aim your weapon at the white disk, take the safety off, and squeeze the trigger

(NOTE: Hear click. Then say:)

Now get into a prone position facing downrange. Load this magazine of _____ ammunition into your weapon. Pull the operating rod back and put the safety on.

We want you to pretend you're in a hasty defensive position on this hill. An enemy patrol has begun firing on you. Just as youstart to return fire, the firing pin breaks in your rifle. You look around and see another rifle nearby. You pick it up and use it to bring fire on the enemy. Fire well-aimed shots as quickly as possible. Keep firing until the target drops or you're out of ammunition.

Are you ready?

Unlock your weapon. Watch the range!

INSTRUCTION SETS 2, 3

For your next test mission, load this magazine of _____ ammunition into your weapon, pull the operating rod back, and put the safety on.

Remember the tactical situation. You are being shot at. Use this rifle to fire well-aimed shots as quickly as possible. Keep firing until the target drops or you're out of ammunition.

Are you ready?

Unlock your weapon. Watch the range!

INSTRUCTION SET 4

And now your final test mission.

Remember the tactical situation.

Load this magazine of_____ammunition into your weapon. Pull the operating rod back and put the safety on.

Are you ready?

Unlock your weapon. Watch the range!